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EXPLORATORY ANALYSIS OF PERSONNEL AND PERFORMANCE:
MOBILE SUBSCRIBER EQUIPMENT FOLLOW-ON OPERATIONAL TEST AND EVALUATION

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Summary

This exploratory research used data from the MSE Follow-On Operational Test and Evaluation to (a) describe the personnel characteristics of MSE operators, (b) describe operator performance on critical MSE tasks, and (c) identify personnel variables which could be used to account for variability in operator performance or predict operator performance. Ten personnel variables and 21 critical tasks were considered. Additional data included test performance data, operator errors and subjective workload ratings. Findings can be applied to the design of future tests and to design of prototype algorithms for personnel selection and prediction of operator performance.

System Description

The Mobile Subscriber Equipment (MSE) is a new battlefield communications system slated to become the backbone of U.S. Army corps and division communications. The MSE system is a Non-Developmental Item procured through GTE and is currently being fielded at Fort Hood, Texas and Fort Gordon, Georgia. It is anticipated that approximately 18,000 soldiers will be MSE-trained, with fielding through FY93 to involve over 50 signal battalions.

MSE integrates the functions of transmission, switching, control, communications security, and both voice and data terminal equipment into one system. As a switched telecommunications system, MSE is extended by mobile radiotelephone and wire access. The heart of the system is node center switches (NCS). These centers provide connections to large extension switches (LEN), small extension switches (SEN), and radio access units (RAU) and are linked together by line-of-sight (LOS) radio trunking. Extension switches allow wire line terminal subscribers (telephone, facsimile, and data) to enter the system. Radio access units provide mobile radiotelephone users an interface to MSE and the ability, through an NCS, to communicate with other mobile and wire telephone users. System control centers (SCC) provide processing capability for data inputs to aid in network management. MSE subscriber service is facilitated by user-owned equipment which includes digital nonsecure voice terminals (DNVT) and mobile subscriber radiotelephone terminals (MSRT). MSE is capable of interfacing with other communications systems, to include combat net radio (CNR) users, NATO and allied military systems, and host nation commercial telephone systems. Major components of MSE (NCS, SCC, LEN, SEN, RAU, and LOS) constitute self-contained assemblages configured in wheeled vans. Major auxiliary equipment for MSE includes generators, 15M and 30M masts, and various antennas. More detailed information on the MSE system is available in FM 11-999E, "Mobile Subscriber Equipment (MSE) Architecture."

Background

During the summer and fall of 1988, the MSE Follow-On Test and Evaluation (FOTE) was conducted at Fort Hood, Texas. This was the first U.S. Army test of MSE as a non-developmental item. This test was in conjunction with the initial fielding of MSE with the 13th Signal Battalion, 1st Cavalry Division. The test was conducted by Electronic Proving Ground (EPG), and the U.S. Army Operational Test and Evaluation Agency (OTEA) was the independent evaluator. A majority of manpower, personnel, training, human factors engineering, system safety, and health hazards (MANPRINT) data were collected and processed by a contractor. A comprehensive report of FOTE findings, to include MANPRINT, is available from OTEA.

In June 1988, the Fort Gordon Field Unit (FGFU) of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) requested support from the ARI Fort Hood Field Unit (FHFU) on the completion of work directed by General Thurman in November 1987. The requested support included analysis of MSE training data, analysis of MSE FOTE data reflecting on personnel and training considerations, and development of a performance test for the standardized evaluation of MSE soldiers. This research project's plan was revised in March 1989 to place increased emphasis on MSE operator (31D and 31F MOSs) performance relative to selection considerations and development of both training and SQT standards. Additionally, in March 1989 EPG requested ARI assistance in developing operator performance algorithms which could be integrated into an existing computer simulation of MSE hardware model. In April 1989, OTEA concurred with the proposed ARI research effort as viable and of interest to them and provided all requested MANPRINT MSE FOTE data.

The purpose of this Interim Report is to consolidate relevant MSE FOTE operator personnel and performance data, describe parameters of these data, and provide data analyses which could impact personnel selection and performance standards. It is suggested that this report and the data presented could be used to: (a) develop prototype personnel selection criteria for future validation testing; (b) develop prototype initial performance distributions and standards; (c) develop prototype operator performance algorithms which, when validated, could be integrated into the EPG MSE model; and (d) suggest areas of potential interest for future (Follow-On Evaluation, Jan-Mar 90) MSE testing. As the collection of the data presented, described, and analyzed in this report was not conducted or supervised by ARI, no statements of data integrity can be made or are implied by this report.

Method

Participants

Personnel and performance data were provided through OTEA for 280 soldiers transitioned into 31D, 31F, or 31W MOSs during the conduct of the MSE FOTE. For this group of soldiers, 86% were men, 159 (57%) were 31Ds, 88 (31%) were 31Fs, and 33 (12%) were 31Ws. Feeder MOSs included 25B, 31C, 31G, 31K, 31L, 31M, 31N, 31Q, 31V, 31Y, 31Z, 36C, 36L, 36M, and 72E; the largest proportion of soldiers (56%) came from the 31M MOS. Ages ranged from 19 to 45 years, time in service ranged from 1 to 20, and years of education ranged from 9 to

17. Standardized test score ranges within this group were from 16 to 99 on the AFQT, 59 to 155 on the ASVAB GT, and 76 to 141 on the ASVAB EL.

Composition of Data

A wide range of both personnel and performance data on these MSE-trained soldiers was obtained. For each soldier, the following personnel data were requested: pre-transition MOS, MSE MOS, DOB, years of education, handedness, gender, date of PMOS, years of service, SQT score, ASVAB GT, ASVAB EL, and AFQT. Not all data were available for each soldier, and some data were suspected to be in error. For each soldier, the following performance data were requested: pretraining test score; posttraining test score; and task completion times for troubleshooting, switch initialization, antenna orientation, essential user bypass (EUB), SCC VDU/GDU operation, SCC initialization, SCC digital map loading, SCC frequency plan management, NCS/LEN set up, LOS set up, RAU set up, SEN set up, SCC set up, MSRT installation, key loading RT-1539 (MSRT/RAU), key loading KY-68 (MSRT/RAU), key loading KG-94 (LEN/NCS/SEN/RAU), key loading KG-82 (NCS/LEN), key loading KY-57 (NCS/LEN/SEN/LOS/RAU), and key loading KY-90 (LEN/SEN). In addition, data were requested on operator errors and subjective workload ratings by task. Not all data were available for each soldier.

No single soldier or single team of soldiers would be expected to perform all listed tasks, as tasks are MOS-specific (31D, 31F, and 31W). The small amount of data available on some tasks precluded meaningful statistical considerations of those tasks, and regression analyses applied to personnel and performance data crosswalks were appreciably restricted (reduced Ns) by missing data. While operator error data in terms of error nature were obtained, no frequency or rate data were available. The workload ratings provided by task were small in number and, for present purposes, only the ratings from the Physical Effort, Mental Effort, and Overall Workload scales were considered in presentations and analyses.

Procedures

All data were obtained from EPG through OTEA and were provided as printouts. Prior to reconfiguration and entry into an ARI data base, some (approximately 3%) of the personnel data were deleted due to integrity challenges (e.g. impossible scores on standardized tests, improbable DOBs [ages] for soldiers, or nonexistent PMOSs). A data screen to accommodate entry of all possible data for each soldier was constructed and used to enter accepted data. The total possible number of data points for each soldier was 80 assuming each soldier had all personnel measures, performed all tasks, and completed all workload scales for each task.

Data were processed by a IBM 4381 mainframe computer using the Statistical Analysis System (SAS) Version 5 software. The predominant programs used provided descriptive statistics on distributions (PROC MEANS and PROC FREQ), PMOS-comparative statistics on task performances (PROC GLM), relationships between variables or measures (PROC CORR), and regression techniques which identify combinations of variables which could aid in

accounting for variability in (PROC RSQUARE) or predicting (PROC STEPWISE) task performance.

All descriptive, correlational, and inferential data analysis outcomes are presented in tabular fashion. The provision of means and standard deviations for all appropriate personnel data distributions and for critical task performance distributions allows for easy identification of any percentile "cuts" desired: the 5th percentile equates to a Z score of -1.65 and the 95th percentile equals a Z score of +1.65 assuming that the underlying measures are essentially normally distributed. Most personnel variables do not grossly violate this assumption, though small Ns for many of the critical task performances preclude the possibility of a normal distribution.

Caution must be exercised interpreting operator task performance data as presented. Many operator tasks were team efforts. Further, across any given task, teams were unequal in size and the composition (membership) of a team could change. The obtained data accorded each team member was that team's total time to completion, and no fair comparison of soldiers' performance could be made using the original data. To produce some standardization which would allow more meaningful representations or comparisons of a soldier's task performance, these data were modified: each soldier was awarded the total man-minutes (total time multiplied by number of team members) needed by the team to complete a task. If a soldier performed the same task more than once, the mean of all performances, in man-minutes, was used as the best measure of that soldier's performance. This single value was entered in the performance data base to represent that soldier. Hence, all performance data for critical tasks used and reported in this research effort represent the total number of man-minutes needed by a team (1 to 5 soldiers) to complete the task.

Findings

This research effort is exploratory. It was designed primarily to provide insight into possible concerns or interests for future tests and evaluations and yield prototype algorithms for operator selection and task performance criteria. For a number of critical tasks, performance data were too few to justify any statistical processing, and for some tasks, the variability of performance was so great as to preclude accountability by any variable in the data base. Also, it was noted that performance on one critical task was often totally unrelated (or negatively related) to performance on another critical task by the same group of operators. In most cases involving regression analyses of personnel variables on task performance, sample sizes represented in outcomes were small because any missing value resulted in the entire observation being discarded.

Tables 2 - 7 provide descriptive information on the personnel characteristics of operators, as summarized in Table 1. Table 8 provides descriptive information on operator performance on critical tasks, and Table 9 offers a comparison of MSE-feeder MOSs in terms of critical task performances. Tables 10 and 11 show significant relationships between and among both personnel variables and critical task performances and the derivation of personnel variable predictors of performance. Table 12 compares communications procedures pre- and posttest performances and MSE MOS groups on

Table 1 - MSE PERSONNEL PROFILE

Personnel Variable	Number	Mean	Standard Deviation	Range
		MOS = 31D		
Years of Age	159	25.7	5.2	19 - 45
Years of Education	148	12.2	.7	11 - 16
Years of Service	159	4.5	3.8	1 - 18
AFQT Score	152	51.0	18.5	16 - 99
ASVAB GT Score	147	104.2	11.7	59 - 155
ASVAB EL Score	142	102.6	10.1	80 - 132
Gender (Men)	89%	N/A	N/A	N/A
Handedness (Right)	91%	N/A	N/A	N/A
		MOS = 31F		
Years of Age	88	25.9	4.5	19 - 40
Years of Education	83	12.2	.9	9 - 16
Years of Service	88	4.1	3.2	1 - 13
AFQT Score	83	54.7	16.4	25 - 98
ASVAB GT Score	84	105.5	11.5	63 - 143
ASVAB EL Score	82	104.5	10.8	76 - 141
Gender (Men)	76%	N/A	N/A	N/A
Handedness (Right)	90%	N/A	N/A	N/A
		MOS = 31W		
Years of Age	33	36.2	4.4	24 - 45
Years of Education	29	13.0	1.4	12 - 17
Years of Service	33	15.0	4.3	2 - 20
AFQT Score	27	56.9	22.3	18 - 95
ASVAB GT Score	28	112.9	13.2	92 - 143
ASVAB EL Score	14	111.2	18.3	76 - 138
Gender (Men)	100%	N/A	N/A	N/A
Handedness (Right)	88%	N/A	N/A	N/A
		Composite Group		
Years of Age	280	27.0	5.9	19 - 45
Years of Education	260	12.3	.9	9 - 17
Years of Service	280	5.6	5.0	1 - 20
AFQT Score	262	52.8	18.4	16 - 99
ASVAB GT Score	259	105.6	12.0	59 - 155
ASVAB EL Score	238	103.8	11.1	76 - 141
Gender (Men)	86%	N/A	N/A	N/A
Handedness (Right)	90%	N/A	N/A	N/A

Table 2 - DISTRIBUTION OF GENDER AND LATERALITY AMONG MSE MOSs

MOS	Gender		Laterality	
	Men	Women	Right	Left
31D	89%	11%	91%	9%
31F	76%	24%	90%	10%
31W	100%	0%	88%	12%
Composite	86%	14%	90%	10%

Table 3 - DISTRIBUTION OF STANDARDIZED TEST SCORES AMONG MSE PERSONNEL

Armed Forces Qualification Test (AFQT)									
MOS	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
31D	2%	8%	22%	22%	13%	13%	12%	5%	3%
31F	0%	4%	16%	19%	24%	20%	6%	10%	1%
31W	11%	0%	7%	19%	15%	15%	15%	11%	7%
Total	2%	6%	19%	21%	16%	16%	10%	7%	3%

ASVAB General Technical (GT)										
MOS	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120-129	130-139	140+
31D	1%	0%	0%	9%	24%	35%	23%	7%	0%	1%
31F	0%	1%	0%	5%	26%	31%	27%	8%	0%	1%
31W	0%	0%	0%	0%	14%	32%	21%	21%	7%	4%
Total	<1%	<1%	0%	7%	24%	34%	24%	9%	1%	1%

ASVAB Electronics (EL)								
MOS	70-79	80-89	90-99	100-109	110-119	120-129	130-139	140+
31D	0%	6%	39%	28%	22%	4%	1%	0%
31F	1%	4%	30%	38%	18%	7%	0%	1%
31W	7%	7%	7%	21%	21%	21%	14%	0%
Total	1%	5%	34%	31%	21%	6%	2%	<1%

Table 4 - DISTRIBUTION OF EDUCATION AMONG MSE PERSONNEL

MOS	Years of Education								
	9	10	11	12	13	14	15	16	17
31D	0%	0%	1%	86%	5%	4%	1%	1%	0%
31F	1%	0%	2%	84%	5%	4%	0%	4%	0%
31W	0%	0%	0%	52%	21%	21%	0%	0%	7%
Composite	<1%	0%	2%	82%	7%	6%	1%	2%	1%

Table 5 - DISTRIBUTION OF TIME IN SERVICE AMONG MSE PERSONNEL

MOS	Years of Service						
	1 - 3	4 - 6	7 - 9	10 - 12	13 - 15	16 - 18	19 - 21
31D	48%	27%	12%	8%	3%	1%	0%
31F	50%	26%	17%	6%	1%	0%	0%
31W	6%	0%	0%	12%	33%	30%	18%
Composite	44%	24%	12%	8%	6%	4%	2%

Table 6 - DISTRIBUTION OF AGE AMONG MSE MOSs

MOS	Age Group						
	17-19	20-24	25-29	30-34	35-39	40-44	45-49
31D	5%	45%	30%	12%	6%	2%	1%
31F	1%	43%	39%	13%	3%	1%	0%
31W	0%	3%	3%	27%	45%	18%	3%
Composite	3%	39%	30%	14%	10%	4%	1%

Table 7 - DISTRIBUTION OF FEEDER MOSs AMONG MSE MOSs

MSE MOS / Feed MOS	31D	(N)	31F	(N)	31W	(N)	COMPOSITE	(N)
25B	0%	0	0%	0	6%	2	1%	2
31C	9%	15	8%	7	3%	1	8%	23
31D*	1%	2	0%	0	0%	0	1%	2
31F*	0%	0	2%	2	0%	0	1%	2
31G	0%	0	0%	0	3%	1	<1%	1
31K	9%	15	0%	0	0%	0	5%	15
31L	5%	8	5%	4	3%	1	5%	13
31M	56%	89	55%	48	0%	0	49%	137
31N	5%	8	15%	13	3%	1	8%	22
31Q	1%	1	0%	0	0%	0	<1%	1
31V	1%	1	0%	0	0%	0	<1%	1
31W*	0%	0	0%	0	3%	1	<1%	1
31Y	0%	0	0%	0	58%	19	7%	19
31Z	0%	0	0%	0	15%	5	2%	5
36C	0%	0	1%	1	0%	0	<1%	1
36L	1%	1	0%	0	0%	0	<1%	1
36M	3%	5	10%	9	0%	0	5%	14
72E	9%	14	5%	4	6%	2	7%	20
TOTAL		159		88		33		280

* Presumed incorrect prior MOS entry on personnel data form

Table 8 - SUMMARY OF MSE OPERATOR CRITICAL TASK PERFORMANCES*

Nature of Task	N	Primary MOS	Mean Time (man/min)	Standard Deviation	Range
Troubleshooting	18	31D	126.0	127.9	16-470
Switch Initialization	10	31F	137.7	141.7	16-372
Antenna Orientation	92	31D	56.5	94.2	1-465
Essential User Bypass	9	31F	14.6	5.7	6-24
SCC VDU/GDU Operation	3	31F	27.0	N/A	8-60
SCC Initialization	5	31W	13.0	N/A	10-18
NCS/LEN VDU Operation	18	31F	61.0	47.2	8-177
NCS/LEN Set Up	28	31F/W	2405.5	2265.5	493-5776
LOS Set Up	87	31D	150.7	79.9	30-408
RAU Set Up	24	31D	181.9	60.3	48-264
SEN Set Up	42	31F	245.9	165.5	35-634
SCC Set Up	7	31W	217.9		155-330
Key Load (KY-68)	2	31D	1.0	N/A	0
Key Load (KG-82)	2	31F	6.5	N/A	5-8
Key Load (KG-94)	22	31F	2.4	2.7	1-11
Key Load (KY-57)	19	31D/F	1.1	.2	1-2
Key Load (KY-90)	3	31F	57.0	N/A	7-108

* Most of the listed tasks constituted team efforts and some tasks were conducted several times by a team, though teams often changed personnel and size. As individual soldier data were desired, the total time for the team to complete the task was multiplied by the number of team members, yielding the total man-minutes required to complete the task. This "total team man-minutes" time for completing a given task was assigned to each team member and averaged across repeated measurements for that team member to compensate for team composition differences. This resulted in a task performance time for each operator reflecting the mean man-minutes for team task completion with which a given soldier was associated.

Table 9 - SUMMARY ANALYSIS OF PRIOR MOS EFFECT ON MSE TASK PERFORMANCE

Task	N	Prior MOSs Involved	F	p	Significant Difference*
Troubleshooting	18	31K, 31L, 31M, 36M, 72E	3.63	.0337	31M < 31L, 31M < 31K
Switch Initialization	10	31C, 31M, 31N, 31Y	9.03	.0121	31C < 31N, 31C < 31Y, 31M < 31Y, 31M < 31N
Antenna Orientation	92	31C, 31D, 31K, 31L, 31M, 31N 31V, 36L, 36M, 72E	0.46	.8972	None
Perform EUB	9	31C, 31M, 31N	1.70	.2601	None
NCS/LEN VDU Operation	18	31C, 31M, 31N 31Y, 72E	1.06	.4139	None
NCS/LEN Set Up	28	31C, 31M, 31N 31Y, 36M, 72E	2.09	.1054	31M < 31N 72E < 31N
LOS Set Up	87	31C, 31D, 31K, 31L, 31M, 31N, 31Q, 31V, 31Y, 36M, 72E	1.13	.3492	31C < 31Y 31L < 31Y 31M < 31Y 31N < 31Y 31V < 31Y 36M < 31Y
RAU Set Up	24	31C, 31K, 31M, 31N, 31V, 36M	1.01	.4385	None
SEN Set Up	42	31C, 31F, 31L, 31M, 31N, 36M 72E	1.79	.1297	31M < 31F** 36M < 31F**
SCC Set Up	7	25B, 31C, 31L, 31N, 31Y	1.10	.5277	None
Key Load (KG-94)	22	31C, 31K, 31L, 31M, 31N, 36M, 72E	1.02	.4494	31C < 72E
Key Load (KY-57)	19	31C, 31D, 31K, 31M, 31Y, 72E	0.07	.9960	None

*Based on exploratory analyses by t tests ($p<.05$). Later more definitive analyses will utilize the more stringent Scheffe's Test.

**31F (and 31D) pre-transition MOSs likely are incorrect data entries.

Table 10 - SIGNIFICANT RELATIONSHIPS OF PERSONNEL AND PERFORMANCE VARIABLES*

Correlations Among Personnel Variables (8)			
Variables	r	N	p
ASVAB GT + AFQT	.680	243	.0001
Years Education + Years in Service	.104	260	.0934
ASVAB GT + ASVAB EL	.547	231	.0001
ASVAB EL + Gender	-.138	238	.0329
ASVAB GT + Years Education	.256	240	.0001
Years in Service + Age	.853	280	.0001
Age + ASVAB GT	.151	259	.0153
Years Education + Age	.236	260	.0001
AFQT + ASVAB EL	.623	225	.0001
ASVAB EL + Years Education	.191	220	.0046
AFQT + Years Education	.189	243	.0031

Correlations Among Critical Task Performances (12)			
Variables	r	N	p
Troubleshooting + Switch Initialization	.998	3	.0383
LOS Set Up + Antenna Orientation	.213	63	.0940
NCS/LEN Set Up + Switch Initialization	.729	8	.0402
RAU Set Up + Antenna Orientation	-.975	6	.0009
LOS Set Up + Key Load (KG-94)	-.999	3	.0334

Correlations Between Personnel Variables and Performances			
Variables	r	N	p
Age + Switch Initialization	.554	10	.0965
AFQT + Troubleshooting	.476	18	.0457
Gender + Key Load (KG-94)	.385	22	.0768
ASVAB GT + LOS Set Up	.271	80	.0150
Years Education + NCS/LEN Set Up	.378	26	.0570
Age + RAU Set Up	-.371	24	.0742
AFQT + LOS Set Up	.295	82	.0072
ASVAB EL + LOS Set Up	.208	80	.0637
Years of Service + Key Load (KG-94)	.653	22	.0010
Handedness + Switch Initialization	.581	10	.0781
Age + Key Load (KG-94)	.628	22	.0017

* Personnel correlations involved 28 possible unique combinations, critical task performance correlations involved 34 possible unique combinations, and correlations between personnel variables and performances involved 96 possible unique combinations. Some possible combinations were precluded due to insufficient data ($N<3$). Non-significant correlations ($p>.05$) are not listed.

Table 11 - OPERATOR PERFORMANCE PREDICTOR PERSONNEL VARIABLES*

Task	Best Combination of Predictors	N	R-Square**
Troubleshooting	Age + Education + GT + EL	16	.401
Switch Initialization	Age + AFQT + GT + EL + Gender + Hand	9	.999
Antenna Orientation	Age + GT + EL + Hand	75	.056
Perform EUB	Age + Years Service + AFQT + GT	8	.970
NCS/LEN VDU Operation	Education + AFQT + GT + EL	13	.267
NCS/LEN Set Up	Age + Education + AFQT + GT + Hand	18	.517
LOS Set Up	Years Service + Education + AFQT + EL	68	.152
RAU Set Up	Education + AFQT + GT + EL + Gender	16	.436
SEN Set Up	Years Service + Education + AFQT + EL + Hand	35	.225
Key Load (KG-94)	Years Service + GT + EL + Hand	20	.606
Key Load (KY-57)	Years Service + Education + AFQT + GT + EL	14	.532

* Total of 10 personnel variables were available; prior MOS was not used as it was treated elsewhere and while gender and handedness were used, some statistical liberties were applied to their coding and processing. For reasons of diminishing returns, a maximum of 5 variables was allowed for any listed combination.

** R-square may be interpreted as the proportion of variance in a task performance which can be accounted for by knowledge of indicated variables.

Table 12 - COMPARISON OF COMMUNICATIONS PROCEDURES TEST PERFORMANCE*

Composite Group							
Pretest Mean	N	Standard Deviation	Posttest Mean	N	Standard Deviation	t	p
43.48%	254	14.79	69.54%	244	10.27	30.68	<.001

MSE MOS Comparisons on Pretest					
F	p	Groups Compared	Difference	p**	Outcome
48.86	<.001	31D, 31F	1.05	>.05	No Difference
		31D, 31W	26.10	<.05	31W > 31D
		31F, 31W	25.05	<.05	31W > 31F

MSE MOS Comparisons on Posttest					
F	p	Groups Compared	Difference	p**	Outcome
18.33	<.001	31D, 31F	5.98	<.05	31F > 31D
		31D, 31W	10.96	<.05	31W > 31D
		31F, 31W	4.98	>.05	No Difference

* Test scores were in terms of percent correct

** Based on application of Scheffe's Test

Table 13 - BEST AVAILABLE PERFORMANCE PREDICTION ALGORITHM*

Task	N	Prediction Equation (Variables and Weights)	R-Square	F	p
Troubleshooting	15	10.64 GT + 271.26 Education - 4245.68	.370	3.53	.062
Switch Initialization	10	12.85 Age + 193 Hand - 438.51	.465	3.05	.112
Antenna Orientation	68	None			
Perform EUB	9	-.20 AFQT + -.12 Pre Test + 31.08	.383	1.87	.234
NCS/LEN VDU Operation	13	1.12 Pre Test + 5.58	.197	2.69	.129
NCS/LEN Set Up	20	533.07 Education + 39.59 AFQT + 5078 Hand - 93.21 Post Test - 4724.88	.584	5.26	.008
LOS Set Up	62	.98 AFQT + 2.82 Pre Test -13.29	.240	9.33	<.001
RAU Set Up	14	None			
SEN Set Up	27	114.15 Education + 135 Hand - 5.92 Post Test - 865.98	.252	2.59	.078
Key Load KG-94	18	.50 Time in Service + .21	.439	12.53	.003
Key Load KY-57	11	-.02 EL + 2.60	.159	1.71	.224

* Variables were accepted into the regression model only if they met the criterion p of F <.50. They were retained in the prediction equation only if they met the criterion p of FL.25 as variables were added to the regression model. An actual prediction equation was provided only if the final R-Square (proportion of performance variance accounted for) F value had a p<.25. For computational purposes, the variable on hand was coded right = 1 and left = 2, units of education, age, and time in service were years, pre and posttest scores were in percents, and AFQT and ASVAB GT were in original standard scores.

Table 14 - SUBJECTIVE WORKLOAD RATINGS FOR MSE TASKS*

Task (Nominal)	N	Mean Workload Rating** Mental Effort	Physical Effort	Overall***
30M Mast Erection	6	3.5	3.0	3.3
RAU Set Up/Initialization	9	2.0	3.2	3.0
Antenna Orientation	5	2.6	2.0	3.0
LOS Set Up/Initialization	15	2.1	2.8	2.4
VDU and Switch Operation	5	2.2	2.0	3.0
Perform EUB	4	2.3	1.0	1.8
Establish Links	3	2.0	2.3	2.7
SEN Set Up/Initialization	10	1.9	2.6	2.2
15M Antenna Set Up	3	1.7	1.7	2.7
Antenna (unknown) Set Up	6	2.8	3.8	4.3
Shelter (unknown) Set Up	6	2.5	3.7	3.0

Task Performance (Actual)	N	Correlation with Workload Ratings** Mental Effort	Physical Effort	Overall
Antenna Orientation	5	-.912 ($p<.05$)	.410	-.076
NCS/LEN VDU Operation	5	.451	-.215	-.207
LOS Set Up	13	-.472	-.147	-.407
RAU Set Up	9	-.473	-.358	-.351
SEN Set Up	10	-.098	-.137	-.030

* Tasks for which there were less than 3 respondents were omitted.

** The rating scales extended from "1" (factor barely contributed to task's overall workload) to "5" (factor is the primary cause contributing to overall workload and one was not able to keep up with work required). Data may not be valid due to poor definition of scale value "1" compared to other scale values and to small samples.

*** Refers to soldiers' ratings of "Overall Workload" for each task — not to average of Mental Effort and Physical Effort ratings.

Table 15 - MSE OPERATOR ERRORS*

Nature of Error	MOS Involved
DSVT affiliation	31D
Cables (J4,J5-J8, J9) in wrong place	31D, 31F
Wrong entry for trans frequency	31F, 31W
Turned switchboard off while troubleshooting	31F
Failed to check oil in generator	31D
Dropped wrong link	31F
AC/DC power selector switch in wrong position	31D
Wrong variables from NCS to SEN	31F
Did not turn over batteries in AKDC	31F
Interconnecting cable not properly connected	31F
Interconnection cables J4 and J5 transposed on NC switch	31F
Cable hooked up at wrong hauk	31D
Improper receiver frequency on GRC-224	31D
Accidental change of frequency on UHF radio	31D
Grounding to generator	31D
Power turned off and system shut down	31D
System control gave wrong frequencies twice	31D
Switching of power supply	31D
NCS ordered shut off of link without authority	31D
Generator ran out of fuel causing loss of AC power	31D, 31F
NC cut off system without notification	31F
No variables to load into equipment	31F
Wrong variable T-key	31F
Bad profile on shot	31D
Forgot to connect power cable to shelter	31D
Power hum on OCU--rerun coax to NC	31D
Zeroized TED accidentally	31F
Guy winder had to be rewound/guy wires rerouted	31D
Timing card switch set in wrong position	31D
Generator died during switch in shifts	31D
SHF antenna fell--not all guy ropes attached	31F

* Frequency of error data not available

those performances. Table 13 provides the best available prediction equations for performance on specific critical tasks based on personnel variables. Table 14 offers descriptive information on subjective workload ratings for specific critical tasks and their relationship to actual task performances. Table 15 lists operator errors recorded during the FOTE.

Summary Interpretation

As an exploratory research effort, no definitive conclusions were warranted or intended. Further, small sample sizes for most critical task performances preclude attributing any great degree of confidence in statistical findings. However, as this research was intended to suggest possible issues for future MSE testing and provide insight into the design of personnel slotting and operator performance prototypes, identification of the more significant findings is appropriate. The following constitutes a summary of the most noteworthy findings.

- No women were in the 31W MOS, and there were proportionately twice as many women in 31F than in 31D.
- There was a disproportionately large number of 31Ws in lower categories of the AFQT (this may impact on the quality of supervision and management).
- 31Ws tended to have more education than other MSE MOSs.
- The predominant feeder MOS for 31D and 31F was 31M; other major feeder MOSs included 31C, 31N, 72E, and 36M.
- The major feeder MOS for 31W was 31Y; 31Z was also a large contributor.
- Very large variabilities in performance times existed for the tasks of troubleshooting, switch initialization, antenna orientation, and NCS/LEN set up (may suggest needs for more, better, or different training on these tasks).
- For troubleshooting, 31L and 31K MOSs were significantly slower in their performance than most other MOSs.
- For switch initialization, 31C and 31M MOSs clearly performed faster than other MOSs.
- For NCS/LEN set ups, 31Ns did poorer than the other major MSE feeder MOSs (31M, 72E).
- For LOS set ups, 31Ys were clearly the poorest performers.
- Significant correlations among personnel variables simply confirm expected relationships among these variables; however, there may be a sex difference on ASVAB EL scores (women appear to have made lower scores than men).

- While tenuous due to small samples, there was an inverse relationship between RAU set up and antenna orientation performances and between LOS set up and loading the KG-94; overall, there was a noticeable absence of relationships between tasks common to an MSE MOS.

- There were numerous significant relationships between certain personnel variables and task performances (Table 10); most of these relationships were positive, the opposite of what might be expected.

- Based on regressions of personnel variables on critical task performances, troubleshooting, switch initialization, EUB, NCS/LEN set up, RAU set up, and key loading appeared fairly open to prediction; LOS set up, NCS/LEN VDU operation, SEN set up, and antenna orientation retained a large proportion of their variances as unpredictable.

- There was a significant improvement in communications procedures test scores (pre vs post training); on both the pre and post test, 31Ws generally scored significantly better than 31Ds or 31Fs, with 31Ds performing the poorest.

- Provision of meaningful performance algorithms for critical tasks was restricted due to large variances and relatively small samples; troubleshooting, NCS/LEN set up, LOS set up, SEN set up, and KG-94 key loading appear as good candidates for algorithms (see Table 13).

- For major MSE tasks, antenna set up and mast erection had the highest overall workload ratings; the highest mental effort rating was for 31m mast erection and the highest physical effort rating was for antenna set up and shelter set up (may relate to manpower requirements).

- More frequently reported operator errors included cabling problems and mistakes, poor generator use procedures and monitoring, and mast and antenna installation problems; most other errors involved wrong or accidentally changed equipment settings.